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51st Internationales Wissenschaftliches Kolloquium
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Atanas Chervenkov and Todorka Chervenkova

Propagation of Solitons in Linear Sructures

ABSTRACT

The propagation of solitary waves in linear structures is considered. The solitary waves are generated in non-linear transmission line. The load of transmision line is investigated linear structure. The linear structures as linear cicuits with distribution parameters are presented. One-dimension solitons in different linear structures is investigated. The analysis is made numerically by different parameters of the transmission line and the linear structures. The results show how the solitary wave penetrates in the linear structures.

THEORETICAL BACKGROUND

The non-linear transmission line presented by non-linear circuit with distribution parameter is investigated.

The processes in the non-linear circuit with distribution parameters with Korteweg-de Vries equation are described [1,2,4].

The non-linearity is determined from the voltage-variable capacitance diode i.e. by the dependence of the capacitance from the voltage $c(u)$. The dispersion is determined from the discrete distribution (space dispersion) and from time scale ω_1 (time dispersion) $\omega = \frac{1}{\sqrt{LC_1}}$.

Only the waves which propagate in the positive direction are investigated.

We use the substitution $u(x,t) \to u(x,\xi)$, where $\xi = \frac{x}{V_0} - t$.

If we reject the high order derivatives, after integration on ξ, we shall obtain the well known Korteweg-de Vries equation [1]

$$\frac{\partial u}{\partial x} - \alpha\rho u \frac{\partial u}{\partial \xi} + \beta\rho \frac{\partial^3 u}{\partial \xi^3} = 0, \tag{4}$$

where: $\rho = \sqrt{\frac{L}{C_0}}$ is the wave impedance;

$\alpha = \frac{dC}{du}\Big|_{u=0}$ is the parameter of non-linearity;

$\beta = \frac{C_0 + 12C_1}{24V_0^2}$ is the parameter of dispersion.

DESCRIPTION OF THE PROBLEM

The computer model on a physical transmission line, realized by researchers in University of Saratov, is made [2].

The solitary waves are generated in non-linear transmission line. It is presented as non-linear circuit with distribution parameters (position 2 in fig. 1) [1,2].

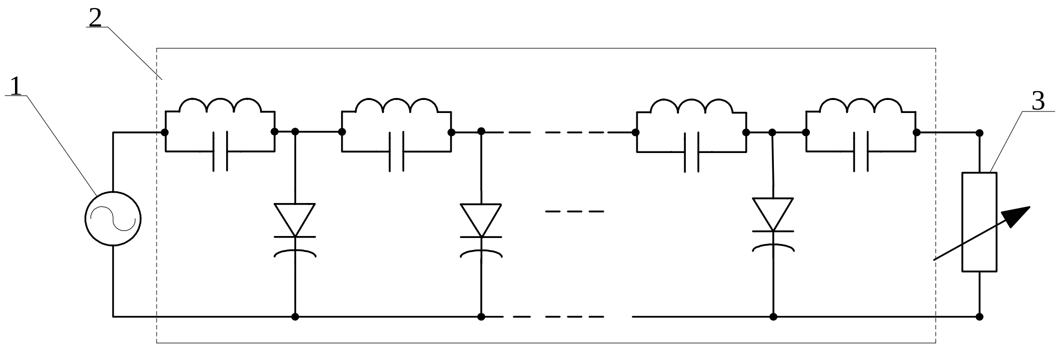


Figure 1. *Non-linear transmission line*

This system is interesting because its creation is easily. The application of this system can be in the communication and other technical and physical areas.

The non-linear circuit consists 30 sections. Each section includes inductance *L*, capacitance C_1 and non-linear capacitance. The voltage-variable capacitance diode *D* as non-linear element is used.

In the input of the transmission line is connected the sine-generator (position 1).

The load (position 3) is connected in the output of the non-linear circuit.

In this investigation the load is presented as linear circuit with distribution parameters – fig. 2.

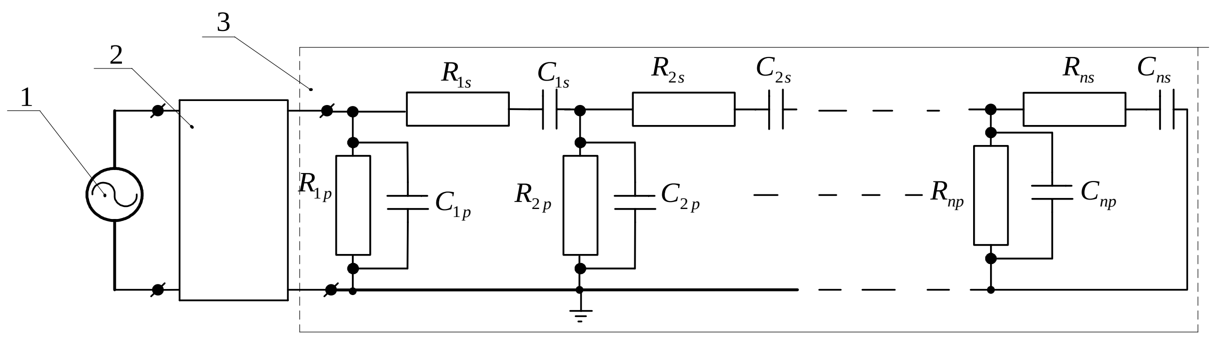


Figure 2. *Load with distribution parameters*

The purpose of this investigation is the propagation of solitons in the linear structure.

RESULTS

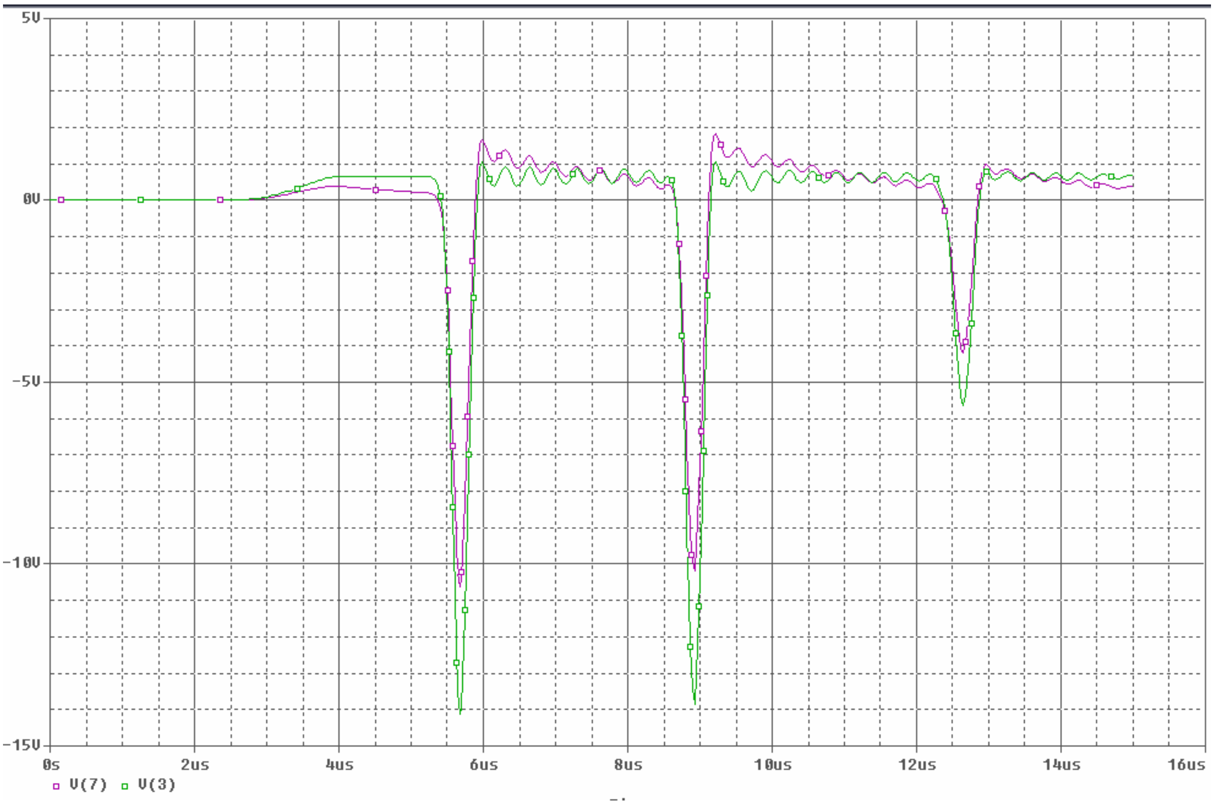
The distribution of the voltage along the non-linear circuit and in the linear structures by numerical analysis is made.

The propagation of the solitons in one-dimension linear structure (fig.2) is investigated on the first order.

The numerical analysis by different parameters of the transmission line and linear structure is made. The non-linear elements with different characteristics are used.

Numerical and graphics results for propagation of the solitons are obtained.

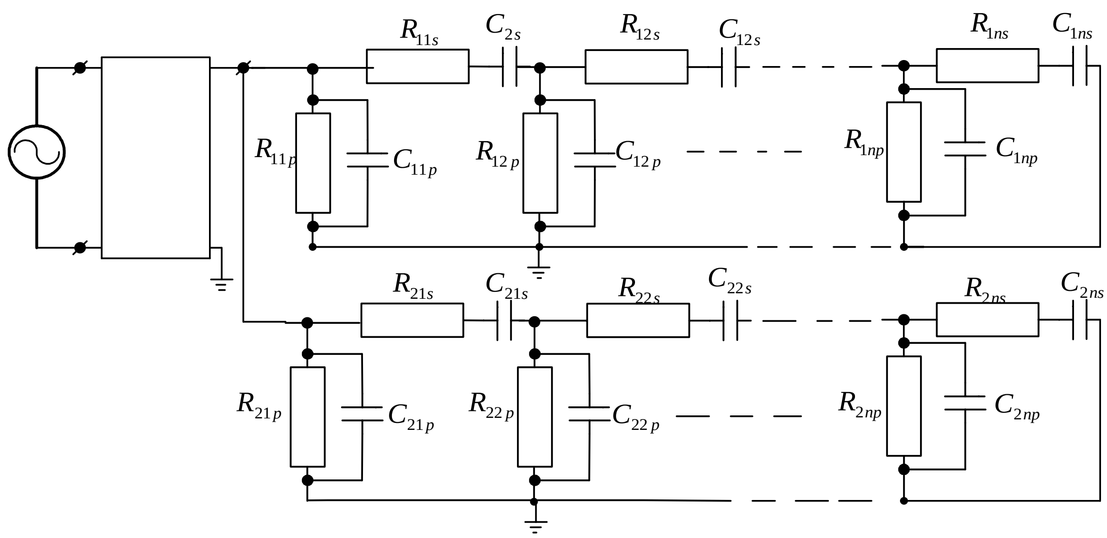
The distribution of solitons of linear structure is represented in fig. 3.



U(3) is potential in the entry, U(7) is the potential in the end of the load

Figure 3. *Distribution of solitons in the linear structure*

The propagation of the solitons in one-dimension linear structure with two parallel loads (fig.4) is investigated on the second order.

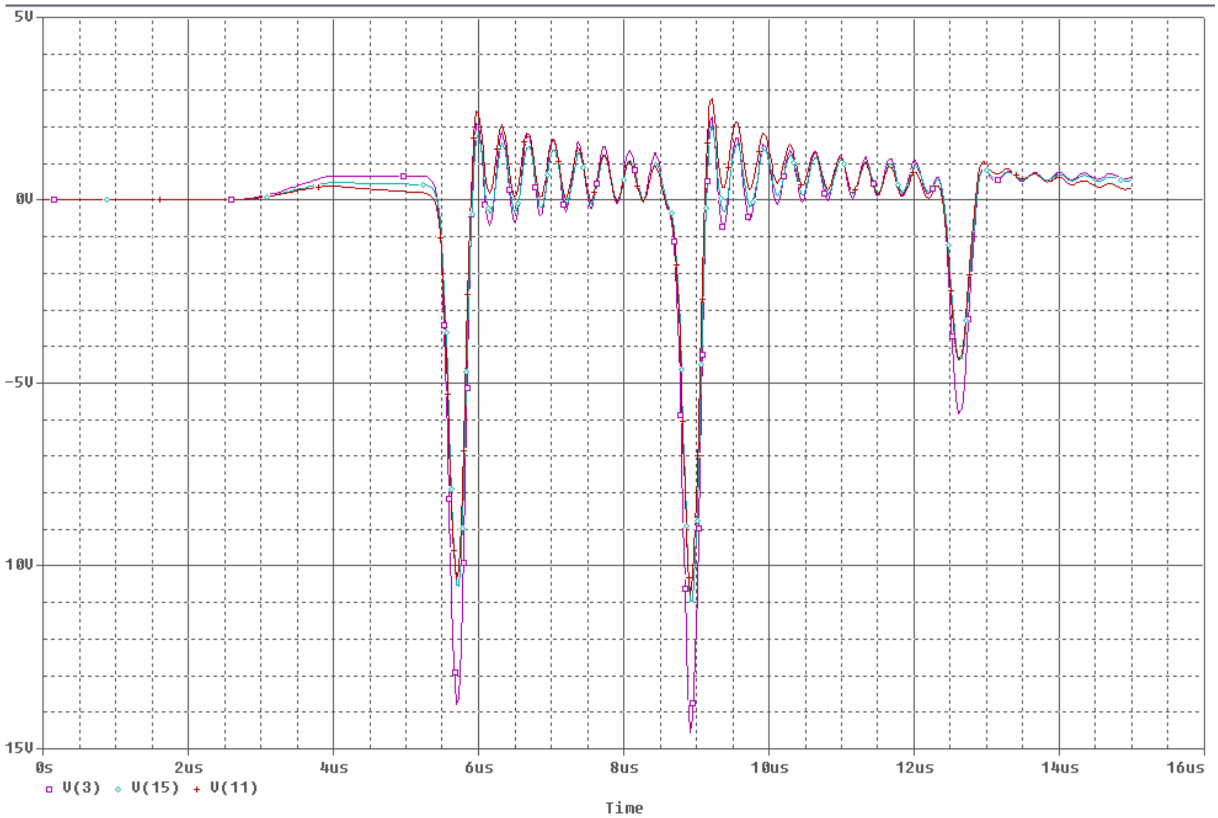


Fighure 4. *Two parallel loads with distribution parameters*

When the parameters of parallel loads i.e R_{11s} and R_{21s} (C_{2s} and C_{21s} ...) are identical the the propagation of the solitons is the same.

When the parameters of parallel loads are different we have new results.

The propagation of the solitons in one-dimension linear structure with two parallel loads with different characteristics is represented in fig. 5



U(3) is potential in the entry, U(11) is the potential in the end of the first load,

U(15) is the potential in the end of the second load

Figure 5. *Propagation of solitons in two parallel loads*

The propagation of the solitons in one-dimension linear structure with three parallel loads (fig.6) is investigated on the last order.

The characteristics of the parallel loads are different.

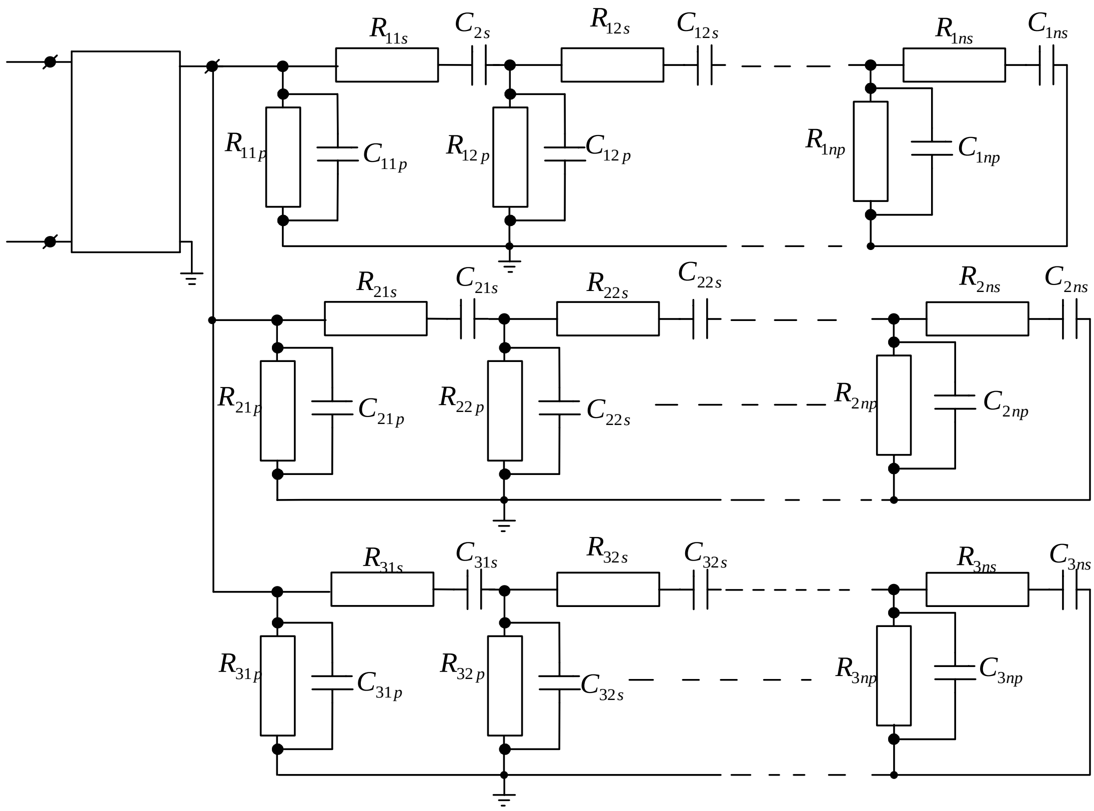
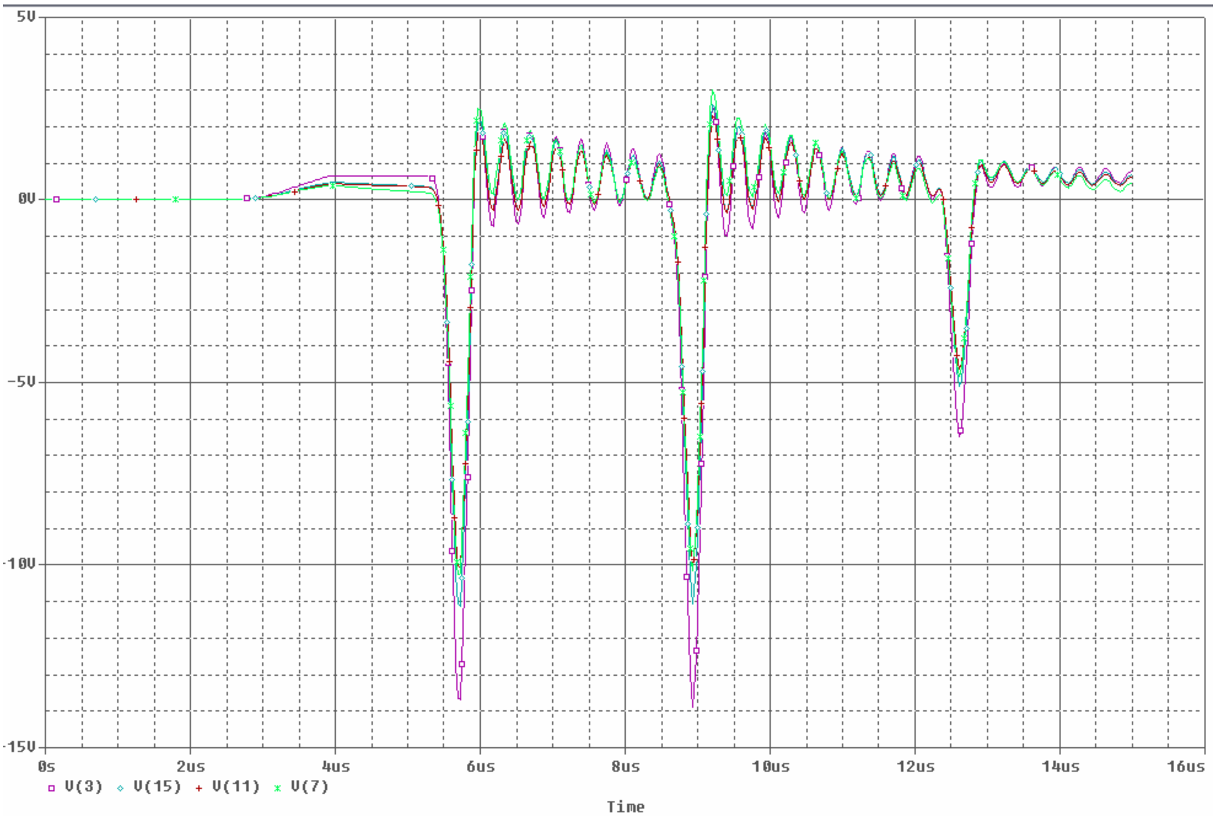


Figure 6. *Three parallel loads with distribution parameters*

The propagation of the solitons in one-dimension linear structure with three parallel loads with different characteristics is represented in fig. 7.

The ratio between characteristics of the loads is 1.0/0.50/0.60.



U(3) is potential in the entry, U(7) is the potential in the end of the first load,

U(11) is the potential in the end of the second load, U(15) is the potential in the end of the third load

Figure 7. *Propagation of solitons in three parallel loads*

The distribution of the soliton amplitudes of the thtree parallel loads along the x-axis for the fixed moment *t* is represented in fig. 8.

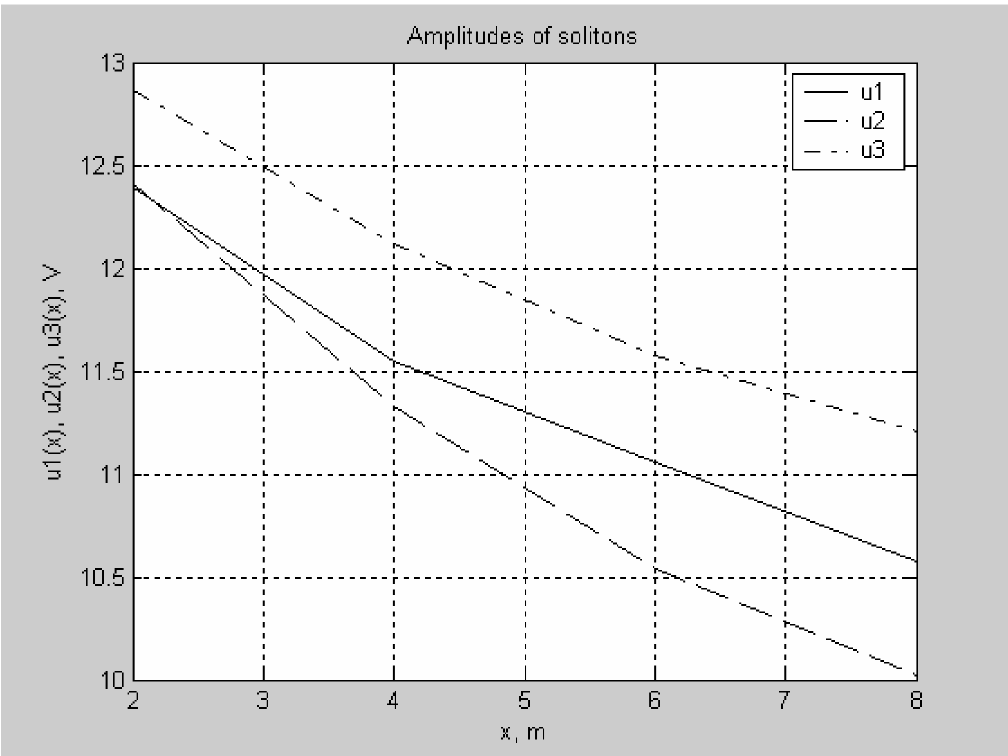


Figure 8. D*istribution of the soliton amplitudes of the parallel load along the x-axis*

CONCLUSION

The propagation of solitary waves in different linear structures and in the non-linear transmission line is investigated.

The distribution of solitary waves depends of the presentation and of the characteristics of the load.

The propagation of solitary waves in case of different characteristics of the linear structures is described.

For the fixed moment *t* the ratio of the amplitudes of the solitary waves is 0.94/0.89/1.0 by ratio of characteristics of parallel loads 1.0/0.50/0.60.

The investigations give possibility to ascertain the penetration of solitons in linear structures.

Acknowledgment

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